


JC10 REC'D JPTO 26 FEB 2002

FORM PTO-1390 (REV 10-2000)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER <div style="border: 1px solid black; padding: 2px; text-align: center;">P/3727-6</div>	
<b>TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371</b>				U.S. APPLICATION NO. (If known, see 37 CFR 1.5) <div style="border: 1px solid black; padding: 2px; text-align: center; font-size: 1.2em;">10/069648</div>	
INTERNATIONAL APPLICATION NO. <div style="border: 1px solid black; padding: 2px;">PCT/RU00/00257</div>		INTERNATIONAL FILING DATE <div style="border: 1px solid black; padding: 2px;">27 June 2000</div>		PRIORITY DATE CLAIMED <div style="border: 1px solid black; padding: 2px;">27 June 2000</div>	
TITLE OF INVENTION <div style="border: 1px solid black; padding: 2px; text-align: center;">PLASMA CHEMICAL REACTOR</div>					
APPLICANT(S) FOR DO/EO/US <div style="border: 1px solid black; padding: 2px; text-align: center;">Mikhail Rudolfovich PREDTECHENSKY</div>					
<p>Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:</p> <ol style="list-style-type: none"> <li>1. <input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li>2. <input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li>3. <input checked="" type="checkbox"/> This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).</li> <li>4. <input type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).</li> <li>5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2))             <ol style="list-style-type: none"> <li>a. <input type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau).</li> <li>b. <input checked="" type="checkbox"/> has been communicated by the International Bureau.</li> <li>c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US).</li> </ol> </li> <li>6. <input checked="" type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).</li> <li>7. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))             <ol style="list-style-type: none"> <li>a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau).</li> <li>b. <input type="checkbox"/> have been communicated by the International Bureau.</li> <li>c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.</li> <li>d. <input checked="" type="checkbox"/> have not been made and will not be made.</li> </ol> </li> <li>8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).</li> <li>9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).</li> <li>10. <input type="checkbox"/> An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).</li> </ol> <p><b>Items 11 to 16 below concern document(s) or information included:</b></p> <ol style="list-style-type: none"> <li>11. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98.</li> <li>12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.</li> <li>13. <input checked="" type="checkbox"/> A FIRST preliminary amendment.  <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment.             <div style="float: right; text-align: right;">EXPRESS MAIL CERTIFICATE</div> </li> <li>14. <input type="checkbox"/> A substitute specification.</li> <li>15. <input type="checkbox"/> A change of power of attorney and/or address letter.</li> <li>16. <input checked="" type="checkbox"/> Other items or information:</li> </ol>					
Print EFS Form Inventor Designation Sheet 1 Drawing Sheet (Fig. 1) Cover Sheet of published PCT Intl. Appln. Intl. Search Report & 7 References		<div style="text-align: center;">         I hereby certify that this correspondence is being          deposited with the United States Postal Service as Express          Mail Post Office to Addresses (mail label          EL924372845US in an envelope addressed to:  <b>U.S. Patent and Trademark Office, P.O.          Box 2327, Arlington, VA 22202 on          February 26, 2002</b> </div> <div style="text-align: center; margin-top: 10px;"> <div style="border-bottom: 1px solid black; display: inline-block; width: 150px;">Dorothy Jenkins</div>          Name of Person Mailing Correspondence            Signature  <div style="border-bottom: 1px solid black; display: inline-block; width: 150px;">February 26, 2002</div>          Date of Signature       </div>			

U.S. APPLICATION NO. (if known) 37 CFR 1.63		INTERNATIONAL APPLICATION NO. PCT/RU00/00257		ATTORNEY'S DOCKET NUMBER P/3727-6	
<b>17. <input checked="" type="checkbox"/> The following fees are submitted:</b> <b>BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):</b> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ..... \$1,040.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... 890.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... 740.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... 710.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) ..... \$100.00  <b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b>				<b>CALCULATIONS</b> PTO USE ONLY	
				\$ 1,040.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	12 - 20 =	0	X \$18.00	\$	
Independent claims	1 - 3 =	0	X 84.00	\$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ 280.00	\$	
<b>TOTAL OF ABOVE CALCULATIONS =</b>				\$ 1,040.00	
<input checked="" type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				\$ 520.00	
<b>SUBTOTAL =</b>				\$ 520.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$	
<b>TOTAL NATIONAL FEE =</b>				\$ 520.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property				\$	
<b>TOTAL FEES ENCLOSED =</b>				\$ 520.00	
				Amount to be refunded:	\$
				charged:	\$
<b>a. <input checked="" type="checkbox"/> A check in the amount of \$ 520.00 to cover the above fees is enclosed.     Check No. 8459</b>					
<b>b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees.            A duplicate copy of this sheet is enclosed.</b>					
<b>c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any            overpayment to Deposit Account No. 15-0700. A duplicate copy of this sheet is enclosed.</b>					
<b>NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR            1.137(a) or (b)) must be filed and granted to restore the application to pending status.</b>					
SEND ALL CORRESPONDENCE TO: <b>OSTROLENK, FABER, GERB &amp; SOFFEN, LLP</b> <b>1180 Avenue of the Americas</b> <b>New York, NY 10036-8403</b>  <b>Tel: (212) 382 0700</b>			 SIGNATURE: <b>Robert C. Faber</b> NAME <b>24,322</b> REGISTRATION NUMBER		

P/3727-6

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

Mikhail Rudolfovich PREDTECHENSKY

Date: February 26, 2002

Serial No.:

Group Art Unit:

Filed:

Examiner:

For: PLASMA CHEMICAL REACTOR

U.S. Patent and Trademark Office  
P.O. Box 2327  
Arlington, VA 22202

Attn: Box PCT (US/DO/EO)

**AMENDMENT/SUBMISSION**

Prior to examination, please amend the application as follows.

**FEE CALCULATION**

Any additional fee required has been calculated as follows:

  X   If checked, "Small Entity" status is claimed.

	NO. CLAIMS AFTER AMENDMENT		HIGHEST NO. PREVIOUSLY PAID FOR		EXTRA PRESENT		RATE	ADDIT. FEE
TOTAL	12	MINUS	20	* =	0	X	(\$9 SE or \$18)	\$
INDEP.	1	MINUS	3	** =	0	X	(\$42 SE or \$84)	\$
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM						X	(\$140 SE or \$280)	\$
								TOTAL \$ -----

\* not less than 20 \*\* not less than 3

If any additional payment is required, a check which includes the calculated fee of \$ \_\_\_\_\_  
(OFGS Check No. \_\_\_\_\_) is attached.

In the event the actual fee is greater than the payment submitted or is inadvertently not enclosed or if any additional fee during the prosecution of this application is not paid, the Patent Office is authorized to charge the underpayment to Deposit Account No. 15-0700.

## CONTINGENT EXTENSION REQUEST

If this communication is filed after the shortened statutory time period had elapsed and no separate Petition is enclosed, the Commissioner of Patents and Trademarks is petitioned, under 37 C.F.R. § 1.136(a), to extend the time for filing a response to the outstanding Office Action by the number of months which will avoid abandonment under 37 C.F.R. § 1.135. The fee under 37 C.F.R. § 1.17 should be charged to our Deposit Account No. 15-0700.

## AMENDMENTS

  X   If checked, amendment(s) to the specification and/or claims are submitted herewith.

1.   X   If checked, an abstract is submitted as the last page of Appendix A. Please replace the present Abstract with the one attached hereto.

### 2. Claims:

Please cancel claims 1-12 without prejudice.

Please add new claims 13-24 pursuant to 37 C.F.R. § 1.121(c)(i) as set forth in the “clean” version attached hereto as Appendix A. Entry is respectfully requested. A version with markings to show the changes made pursuant to 37 C.F.R. § 1.121(c)(ii) is attached hereto as Appendix B.

       If checked, the optional complete set of “clean” claims pursuant to 37 C.F.R. § 1.121(c)(3) is attached hereto as Appendix C.

REMARKS/ARGUMENT

This Preliminary Amendment is being submitted to place the claims and Abstract in a better form for U.S. practice.

EXPRESS MAIL CERTIFICATE

I hereby certify that this correspondence is being deposited with the United States Postal Service as Express Mail to Addressee (mail label # EL924372845US) in an envelope addressed to: U.S. Patent and Trademark Office, P.O. Box 2327, Arlington, VA 22202, on February 26, 2002:

Dorothy Jenkins

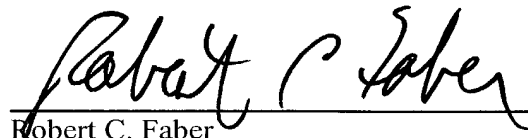
Name of Person Mailing Correspondence

  
Signature

February 26, 2002

Date of Signature

Respectfully submitted,

  
Robert C. Faber

Registration No.: 24,322

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**APPENDIX A**  
**“CLEAN” VERSION OF EACH PARAGRAPH/SECTION/CLAIM**  
**37 C.F.R. § 1.121(b)(ii) AND (c)(i)**

**CLAIMS (with indication of amended or new):**

(New) 13. The plasma chemical reactor including the reaction chamber, the means for supplying the reaction chamber with plasma forming gas, and the means for the removal of the aim product from the reaction chamber, and at least a pair of electrodes in the reaction chamber, which are disposed in such a way that voltage applied between them strikes an arc discharge in the space between the electrodes, is characterized by the form of each electrode, which is an open metal-filled container, and by the means for supplying the reaction chamber with plasma forming gas which feeds the reaction supplying the reaction chamber with plasma forming gas which feeds the reaction chamber with plasma forming gas between the electrodes to form the vortex flow of the gas in the space between the electrodes.

(New) 14. The plasma chemical reactor according to claim 13, characterized by the melting of the metal filling the electrode containers induced by the arc discharge.

(New) 15. The plasma chemical reactor according to claim 13, characterized by the horizontal arrangement of the electrodes in the reaction chamber.

(New) 16. The plasma chemical reactor according to claim 13, characterized by the reaction chamber equipped with additional inlets for individual reagents and reaction mixture.

(New) 17. The plasma chemical reactor according to claim 13, characterized by the electrode containers and the means for the supply of the reaction chamber with plasma forming gas are produced from heat-resistant dielectric material.

(New) 18. The plasma chemical reactor according to claim 13, characterized by each electrode container being provided with the chute for filling it with metal.

(New) 19. The plasma chemical reactor according to claim 13, characterized by each electrode container being provided with the means for voltage supply to filling metal, made as a channel with metal connector, one end of which is brought in contact with the metal filling the container and melts together with the filling metal and the second end connected with the contacts for voltage supply remains solid.

(New) 20. The plasma chemical reactor according to claim 13, characterized by the means for the reaction chamber supply with plasma forming gas made as vertical wall at the bottom of the chamber provided with the discharge channel and internal gas channels with one end brought into the discharge channel and the other connected with at least one source of plasma forming gas located at such an angle to the wall of the discharge channel that plasma forming gas forms the vortex in the discharge channel.

(New) 21. The plasma chemical reactor according to claim 20, characterized by the discharge channel made as a cylindrical hole through the wall of the means providing the reaction chamber with plasma forming gas.

(New) 22. The plasma chemical reactor according to claim 20, characterized by tube-like discharge channel placed in the wall of the device for supplying of the reaction chamber with plasma forming gas, and bent in such a way that its ends were directed towards the electrode surface.

(New) 23. The plasma chemical reactor according to claim 20, characterized by the discharge channel equipped at least with one vortex chamber.

(New) 24. The plasma chemical reactor according to claim 23, characterized by vortex chamber made as a cylindrical groove of larger diameter than the diameter of the discharge channel, the axis of which coincides with the axis of the discharge channel, and the gas channels are made at some angle to the side walls of the vortex chamber to produce the vortex flow of the gas.

[illegible]

i



## PLASMA CHEMICAL REACTOR

## Field of Art

5 The invention relates to a chemical reactors employing electric discharge plasma as the source of high temperature. This reactor can be used in chemical engineering, metallurgy and other industries for the production of such chemical products as gas synthesis, hydrocarbons etc., as well as in environment control, health protection, biosphere preservation as an effective device for the decomposition of depleted persistent toxic agents and their removal from industrial exhaust and waste.

## State of the Art

10 Plasma chemical reactors are well known. Their main element is a discharge chamber provided with two electrodes and with an inlet and outlet for plasma forming gas. Thus there are plasma chemical reactors employing some inert gas such as nitrogen, argon or hydrogen as a plasma forming gas. Plasma is formed in the reactor by exciting the  
15 plasma forming gas with an electric discharge in a specially equipped chamber and then fed to the separate reaction chamber with the reaction mixture where the plasma induces chemical reactions yielding the desired target product.

Among such reactors we can name, for instance, the device for high-temperature chemical reactions yielding powders of high-purity metals of IVb, Vb, VIb groups of the  
20 periodical table, i.e. titanium, tungsten, molybdenum etc., or their alloys as well as for the halogenation of metal oxides and the synthesis of hydrocarbons such as acetylene, gasoline etc. The device is equipped with a plasma generator producing plasma by means of an electrical discharge between the anode and cathode when plasma forming gas such as argon or nitrogen is fed there. The plasma from the generator and gaseous reaction mixture  
25 are fed to a special reaction zone in the device below the anode. A chemical reaction proceeding afterwards in the reaction zone yields the desired product. After the reaction the flow of the reaction mixture containing the desired product is quenched in the quenching zone and separated into several flows later combined in a collector zone where the pure target product is extracted (US patent № 384050).

30 One of the well-known devices is also a plasma reactor for the thermal cracking of substances, mainly hydrocarbons. The plasma is generated in a discharge chamber specially equipped with axially fixed anode and cathode between which an electrical arc is

formed, through which a plasma forming gas – hydrogen or nitrogen – is passed. The discharge chamber is connected with a mixing chamber where all the necessary reagents forming the initial hydrocarbon reaction mixture of preset composition are fed. Then the initial reaction mixture heated to several thousands degrees Celsius is introduced directly  
5 into the reaction chamber where the desired product is formed. The target product is isolated via subsequent rapid cooling of the reaction mixture by cold quenching gas in the free space over the reaction chamber. Then the final product is fed to the scrubber to wash the gas off (U.S. patent № 3622493). The above-described plasma chemical reactors are bulky, have complicated design and are expensive. In addition the service life of electrodes  
10 in the discharge chamber is rather short because of the erosion caused by high voltage, strong currents and plasma particle bombardment of the surface which necessitates their frequent replacing requiring too many shutdowns of the reactors.

Some plasma chemical reactors are known where the reaction gas serves directly as the plasma forming gas. Their design is much simpler than that of those described above  
15 because they have a single reaction chamber equipped with pair of electrodes through which the reaction gas is passed between them under the application of high voltage striking an electric arc discharge. Among the plasma chemical reactors of the similar design are, for instance, the reactor whose reaction chamber is equipped with an anode and cathode to which high voltage is applied, as well as with inlet and outlet devices for  
20 reagent inlet and the outlet of the target product (U.S. patent № 3658673). The reaction mixture is passed between the electrodes and set into forward-rotary motion leading to the formation of vortex stabilizing the plasma arc between electrodes. In this reactor the electrodes in addition to the above-mentioned factors are exposed to the aggressive chemical medium, their surface is soon eroded and unusable and are to be replaced  
25 frequently (every several hours. The electrodes erosion increases with the increasing in the electrical discharge current thus limiting the maximum current value and imposing restriction on the maximum productivity of plasma chemical reactor.

There is also a plasma chemical reactor for the thermal decomposition of chemical industrial waste. The reactor consists of the reaction chamber with two electrodes between  
30 which the treated gas mixed with the oxygen at the voltage of 100 – 3000 V causing current of 50 - 1000 A (U.S. patent № 5206879). This reactor, as well as above-mentioned ones, requires frequent (every several hours) electrodes replacement, because the presence

of oxygen significantly accelerates the erosion of the electrodes. All this also imposes constraints on its productivity.

#### Disclosure of the invention

5       The object of the present invention is the sufficient prolongation of the plasma chemical reactor electrodes service life with corresponding decreasing of the expenses of its exploitation and increasing of the reactor productivity.

      This is attained by the suggested design of a plasma chemical reactor consisting of reaction chamber, means for supplying the plasma forming gas and the means for removal  
10   the aim product, at least a pair of electrodes placed in the reaction chamber, so as to provide a gas arc formation in the electrode gap on the application of the electric voltage. Each electrode is shaped as an open container filled with metal and the means for supplying the reaction chamber with plasma forming gas to be fed to the electrode gap as a vortex.

15       The electrodes in the reaction chamber should be arranged horizontally, because the electrical arc initially emerging between solid electrodes gradually melts them and in the course of long-time operation the electrodes become liquid. For example, each container can be made as a tank at the bottom of the chamber, with the setting from the refractory material with dielectric properties, i.e. ladle brick. The container is filled with metal pieces,  
20   particles or ordinary scrap metal. To maintain the arc discharge at voltage supply to the electrodes, the ratio of such technological parameters as voltage value, the distance between electrodes, the consumption of plasma forming gas fed to the chamber, its composition, etc, specified for each construction separately, is important.

      The melting of the metal in the containers because of the electrical arc leads to the  
25   liquefaction of the electrodes working surfaces (the surfaces, between which an electrical arc burns) during the reactor operation, so the electrode is not subject to erosion in the broad sense, but rather to the slow evaporation of the metal and the decrease in its mass. Due to the big mass of the electrode, the reactor can operate for a long time without stops – depending on the volume of electrode container and the velocity of the metal evaporation.

30       To additionally increase the period of continuous operation of the reactor, it is necessary to provide every container with a metal supply means. Those can have the shape of chutes going to containers, along which metal pieces are fed.

The voltage is supplied to the electrodes directly through the metal filling the containers. For this purpose every container is provided with special means for voltage supply to the filling metal, which may be designed as a channel with a metal conductor inside, one end of which is connected with the container, melts together with the filling metal, and the other end, connected with the contacts for the electrical voltage supply, remains solid. Hearth water-cooled electrode may also be used for the same purpose.

The means for the supply of plasma forming gas to the reaction chamber between electrodes can have different constructions. It is important for the means to form a vortex gas flow stabilizing the electric arc and precluding the contact between the electrical arc and chamber parts. One of acceptable and simple designs of this means includes the wall made of refractory dielectric material. Its size can be different, but height and width must prevent the arc discharge established at voltage supply to electrodes from bending around this wall. The wall may be made as a partition between the bottom and ceiling of the reaction chamber, dividing its volume in two parts, if it is technically feasible. There is a discharge channel directing the arc discharge in the wall. It may be made as a central through cylindrical hole or as a tube fixed in such a hole and bent in such a way that its ends were directed towards the surface of electrodes. Gas channels connected with the discharge channel and a plasma forming gas source through which the plasma forming gas is injected directly to inter-electrode space. The electric arc is formed in the discharge channel on the wall and enters the reaction chamber volume between electrodes on the both sides of this wall.

In order to stabilize the arc discharge, the plasma forming gas is set into rotation with vortex formation. The resulting vortex must form a cooler and therefore denser plasma forming gas layer between the electric arc and the discharge channel wall which insulates the chamber walls and its other parts. For this purpose gas channels are placed at an angle to the surface of the discharge channel they are connected with, i.e. the gas is introduced tangentially. The plasma forming gas enters the discharge channel at an angle to its wall and then forms a vortex.

If the discharge channel is not sufficient for the vortex formation, the means for the supply of plasma forming gas to the reaction chamber can be additionally equipped with a vortex chamber of a well-known design. For example, it can be shaped as a cylindrical groove inside the channel wall of means reaction gas supplying, which is connected with

the discharge channel and has bigger diameter than that of the channel, and the gas channels are brought out to its walls at an angle. The successive arrangement of several vortex chambers in the discharge channel is also possible. In this case plasma forming gas passes through every chamber and it can be of one composition and fed through all the channels from the same source or its composition may differ and multiple sources of plasma forming gas can be used.

The walls of discharge channel can be cooled by water to prevent their destruction by high temperatures.

The reaction chamber volume must be much larger than the above-mentioned device serving as the plasma source for sustaining plasma chemical reactions. The plasma forming gas is heated to high temperature in the discharge channel and is passed into the reaction chamber volume where it is combined with other reagents or the reaction mixture and induces the further chemical reaction.

There are different ways of conducting chemical reactions in the reactor. Thus, plasma forming gas fed through a special means can be an inert gas such as argon, nitrogen, etc., or reaction mixture specially prepared outside the chamber, or individual reagents involved in the aim reaction. When a plasma forming inert gas or individual reagents are used the reaction chamber must be equipped with special conduits for dispensing the prescribed quantities of the reaction mixture made outside the chamber or all the necessary reagents (liquid, solid, gaseous). If the plasma forming gas is reaction mixture, additional device for supplying the specific gas or individual reactants can be provided, if necessary.

For the aim product output from the reaction chamber it is equipped with the means for its removal.

To fire an electrical arc and to start the operation of the reactor the well-known methods are used:

1. Electrodes are linked through the discharge channel by a wire connector. Plasma forming gas is passed to the chamber through gas channels, and electrical current is applied to the electrodes. The wire connector instantly becomes hot and explodes generating a plasma channel striking an arc discharge.

2. Metal plates – electrode links – are installed into the discharge channel walls. The plasma forming gas is fed through the gas channels and simultaneously the

voltage is applied to the electrodes. Further, high-voltage pulse is sent to the electrode links, resulting in the plasma forming gas break-down, which in its turn initiates the formation of arc discharge.

The required reactions take place in the reaction chamber under high temperatures of arc discharge and electric arc effects the melting of electrode metal filling the containers, which are eventually filled with melted metal.

Since waste accumulation in electrode containers is possible in the course of the reactor operation, waste removal devices can prove useful, e.g. every container could be equipped with a siphon.

#### Brief description of the Figures

Figure 1 shows the scheme of the reaction chamber of the plasma chemical reactor where:

(1) – reaction chamber, (2) – electrode container, (3) – metal filling the electrode container, (4)- chute for providing electrode container with metal, (5) – a wall in the electrode gap, (6) – discharge channel, (7) – aim product outlet, (8) – gas channels for plasma forming gas, (9)- vortex chamber, (10) – additional inlets for reaction gas and reagents, (11) – device for voltage supply to electrode container, (12) – device for slag removal.

#### Best Modes Carrying-Out the Invention

By way of example of plasma chemical reaction operation synthesis-gas production process can be considered. The reactor contains a large volume reaction chamber (1) with two refractory lining tanks (2), filled with scrap iron (3), at the bottom. Each tank has a special channel with a connector for electrical voltage supply directly to the scrap metal in the tank (11). Vertical wall of the refractory brick (5), fixed at the bottom of the chamber (the wall is not connected with the ceiling of the chamber) is placed between the tanks. This wall has such a height and width that arc discharge is unable to bend around it when the voltage is applied to the electrodes. There is a tube-like discharge channel (6), bent in such a way that its ends (and outlets accordingly) were directed to the surface of the electrodes in the wall. The vortex chamber is shaped as an additional groove in the discharge channel with the diameter lager than that of the channel itself. There are also gas

channels (8) for plasma forming gas, one end of which is connected with the source of this gas, and the other end tangentially entering the vortex chamber (9). The length of the discharge channel must be sufficient for the plasma forming gas entering through gas channels to form a vortex, able to stabilize the electric arc. The reactor is started up by the initiation of electrical breakdown by a high-voltage electrical pulse. Further, reagents – hydrocarbons and water steam - are fed to the chamber volume through a special conduit in the ceiling of the chamber (10). Plasma is a source of high temperature necessary for chemical reaction to proceed. Small quantities of iron vapors coming from the molten electrode surface are the catalyst of the reaction yielding synthesis –gas increasing the reaction rate. The target product i.e. the synthesis gas is withdrawn from the reaction chamber through two outlets in the opposite walls (7). Coal, natural gas or other hydrocarbons, instead of vapor, or oxygen-vapor mixture can be put into the reaction chamber. Inert gas, water steam, natural gas or other suitable substances can be used as plasma forming gas. To additionally increase the productivity of the plasma chemical reactor it is possible to increase the volume of its reaction chamber. The chutes (4) serve to fill the electrode containers with metal. There are siphons (12) for slag removal from the electrode surface.

When used for other chemical processes the reactor can be customized and further developed.

In the present plasma chemical reactor the service life of the electrodes is fairly long because they have big mass and their surface during the reactor operation is in molten state. The liquid surface of the electrodes is not prone to erosion, so no shutdown of the reactor for the electrode replacement will be necessary.

### Industrial Applicability

Plasma chemical reaction may be applied in metallurgy, chemical and other industries for the production of chemical products and in environment protection for treating noxious production waste.

# Claims

1. The plasma chemical reactor including the reaction chamber, the means for supplying the reaction chamber with plasma forming gas, and the means for the removal of the aim product from the reaction chamber, and at least a pair of electrodes in the reaction chamber, which are disposed in such a way that voltage applied between them strikes an arc discharge in the space between the electrodes, is characterized by the form of each electrode, which is an open metal-filled container, and by the means for supplying the reaction chamber with plasma forming gas which feeds the reaction chamber with plasma forming gas between the electrodes to form the vortex flow of the gas in the space between the electrodes.
2. The plasma chemical reactor according to claim 1, characterized by the melting of the metal filling the electrode containers induced by the arc discharge.
3. The plasma chemical reactor according to claim 1, characterized by the horizontal arrangement of the electrodes in the reaction chamber.
4. The plasma chemical reactor according to claim 1, characterized by the reaction chamber equipped with additional inlets for individual reagents and reaction mixture.
5. The plasma chemical reactor according to claim 1, characterized by the electrode containers and the means for supplying the reaction chamber with plasma forming gas are produced from heat-resistant dielectric material.
6. The plasma chemical reactor according to claim 1, characterized by each electrode container being provided with the metal supply means.
7. The plasma chemical reactor according to claim 1, characterized by each electrode container being provided with the means for applying voltage to the container filling metal, made as a channel with metal connector, one end of which is brought in contact with the metal filling the container and melts together with the filling metal and the second end connected with the contacts for voltage supply remains solid.
8. The plasma chemical reactor according to claim 1, characterized by the means for supplying the reaction chamber with plasma forming gas made as vertical wall at the bottom of the chamber provided with the discharge channel and internal gas channels with one end brought into the discharge channel and the other connected with at least one source of plasma forming gas located at such an angle to the wall of the discharge channel that plasma forming gas forms the vortex in the discharge channel.



9. The plasma chemical reactor according to claim 8, characterized by the discharge channel made as a cylindrical hole through the wall of the means for supplying the reaction chamber with plasma forming gas.
10. The plasma chemical reactor according to claim 8, characterized by tube-like discharge channel bent in such a way that its ends are directed towards the electrode surface and placed in the wall of the means for supplying the reaction chamber with plasma forming gas.
11. The plasma chemical reactor according to claim 8, characterized by the discharge channel equipped with at least one vortex chamber.
12. The plasma chemical reactor according to claim 11, characterized by vortex chamber made as a cylindrical groove of larger diameter than the diameter of the discharge channel, the axis of which coincides with the axis of the discharge channel, and the gas channels are made at some angle to the side walls of the vortex chamber to produce the vortex flow of the plasma forming gas.

## ABSTRACT

### PLASMA CHEMICAL REACTOR

The reactor contains the reaction chamber 1, the means for the removal of aim  
5 product from the reaction chamber 7, at least a pair of electrodes in the reaction chamber,  
each made as an open container 2 filled with metal 3, placed in such a way that voltage  
applied between them strikes an arc discharge in the space between electrodes, and the  
means for supplying the reaction chamber with plasma forming gas which feeds the  
reaction chamber with plasma forming gas to form the vortex flow of the gas in the space  
10 between the electrodes.

1/1

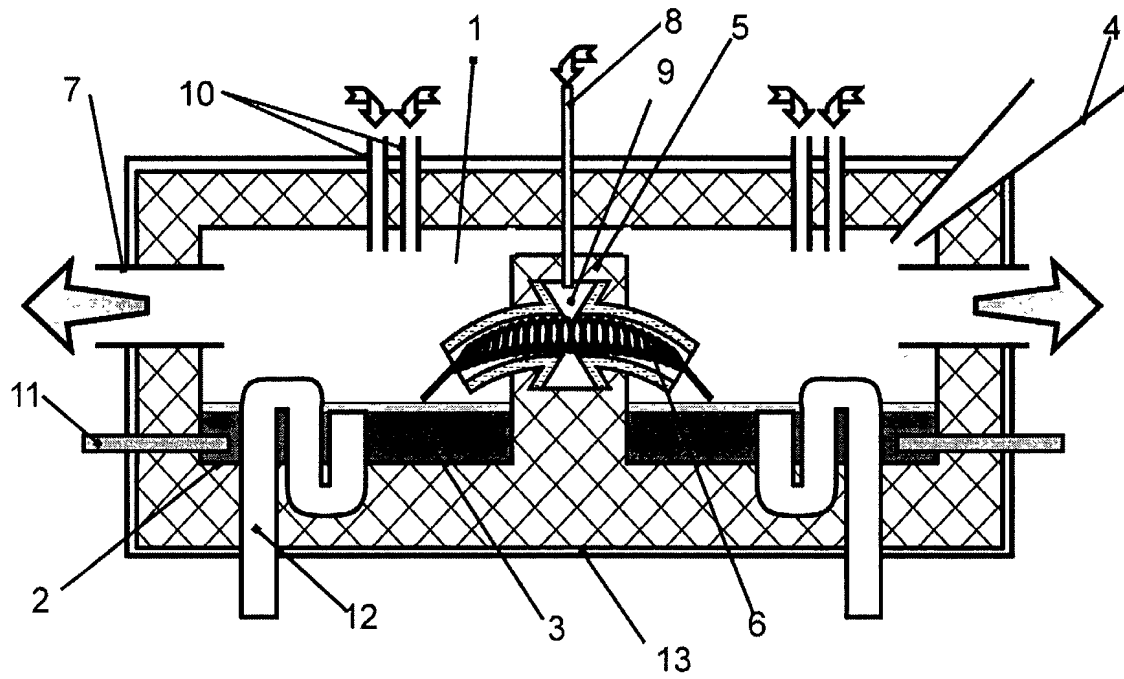


Fig. 1

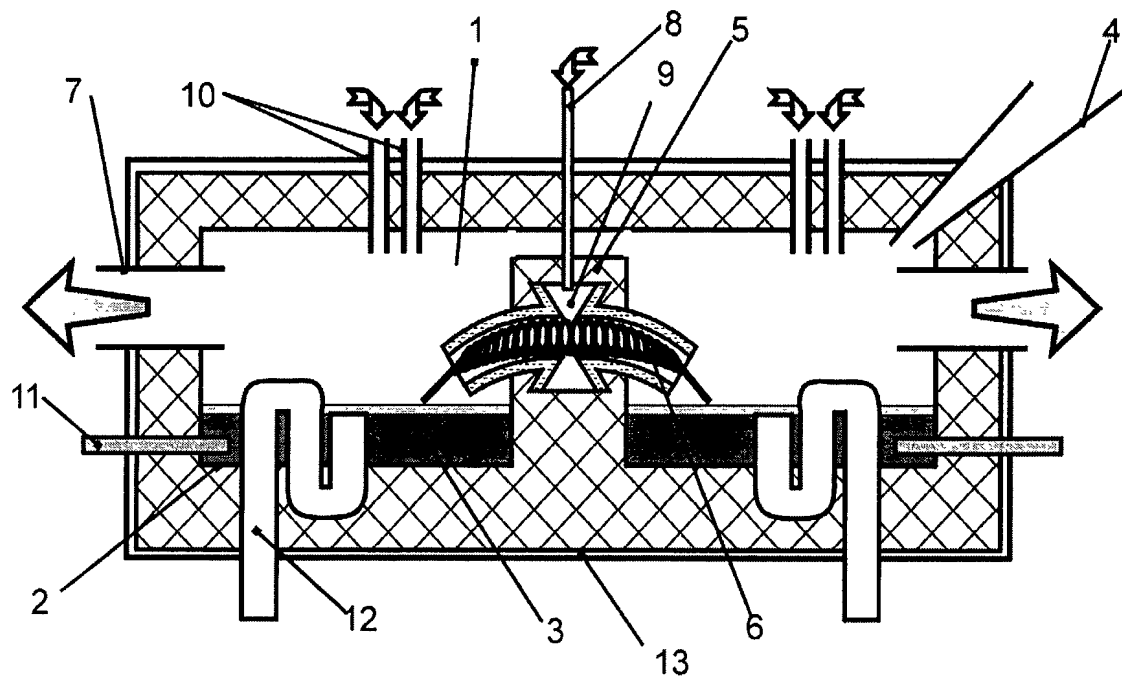


Fig. 1

**23 MAY 2002**  
**48**

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COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION		701010648
<p>As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that I verily believe that I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named) of the subject matter which is claimed and for which a patent is sought on the invention entitled:</p> <p style="text-align: center;"><b>"Plasma Chemical Reactor"</b></p>		
<p>the specification of which is attached hereto, unless the following box is checked:</p> <p><input checked="" type="checkbox"/> was filed on <u>June 27, 2000</u> as <u>United States patent Application Number or PCT International patent</u>  <u>application number PCT/RU00/00257</u> and was amended on _____ (if any).</p>		
<p>I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.</p> <p>I acknowledge the duty to disclose all information known to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.</p> <p>I hereby claim priority benefits under Title 35, United States Code §119 of any foreign application(s) for patent or inventor's certificate or United States provisional application(s) listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:</p>		
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COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)
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		YES _____ NO _____
<p>I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.</p>		
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<p>I hereby appoint customer no. 2352 OSTROLENK, FABER, GERB &amp; SOFFEN, LLP, and the members of the firm, Samuel H. Weiner - Reg. No. 18,510; Jerome M. Berliner - Reg. No. 18,653; Robert C. Faber - Reg. No. 24,322; Edward A. Meilman - Reg. No. 24,735; Stanley H. Lieberstein - Reg. No. 22,400; Steven I. Weisburd - Reg. No. 27,409; Max Moskowitz - Reg. No. 30,576; Stephen A. Soffen - Reg. No. 31,063; James A. Finder - Reg. No. 30,173; William O. Gray, III - Reg. No. 30,944; Louis C. Dujmich - Reg. No. 30,625 and Douglas A. Miro - Reg. No. 31,643, as attorneys with full power of substitution and revocation to prosecute this application, to transact all business in the Patent &amp; Trademark Office connected therewith and to receive all correspondence.</p>		
<p>SEND CORRESPONDENCE TO: <b>OSTROLENK, FABER, GERB &amp; SOFFEN, LLP</b>          1180 AVENUE OF THE AMERICAS          NEW YORK, NEW YORK 10036-8403          CUSTOMER NO. 2352</p>		<p>DIRECT TELEPHONE CALLS TO:          (212) 382-0700</p>
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<p>FULL NAME OF SOLE OR FIRST INVENTOR  <b>Mikhail Rudol'fovich PREDTECHENSKY</b></p>		<p>INVENTOR'S SIGNATURE  <i>Mikhail Rudol'fovich PREDTECHENSKY</i></p>
<p>RESIDENCE (City and either State or Foreign Country)  <b>Russian Federation, Novosibirsk</b></p>		<p>DATE  <b>March 18, 2002</b></p>
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<p>FULL NAME OF SECOND JOINT INVENTOR (IF ANY)</p>		<p>INVENTOR'S SIGNATURE</p>
<p>RESIDENCE (City and either State or Foreign Country)</p>		<p>DATE</p>
<p>POST OFFICE ADDRESS</p>		<p>COUNTRY OF CITIZENSHIP</p>
<p>FULL NAME OF THIRD JOINT INVENTOR (IF ANY)</p>		<p>INVENTOR'S SIGNATURE</p>
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